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of

The Danish Biological Station

to

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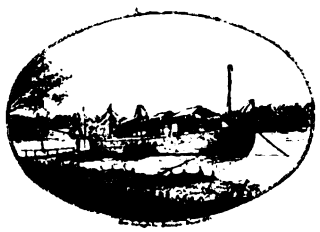

III.

1892.

By

C. G. Joh. Petersen,
Ph. D.

Reprinted from **Fiskeri-Beretningen for 1892--93.**

1893.

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The pelagic life in Fænø Sound.

On the 4. of April 1891 the Biological Station arrived at *Fænø*, on the th-eastern part of which, at Espenhoved, it was moored by 4 anchors, so that it in the strong current (strong, especially, when coming from the south) which runs ough the Fænø Sound. From this place our operations could be extended over following seas (cmp. the chart): Fænø Sound and the current-seas from Middel- t as far as Stenderup Hage, moreover, Gamborg and Kolding Fjords, and the thern part of the expansion between Funen and Sleswick south of Fyns-Skov l Stenderup, waters which are certainly inconsiderable in extent, but which vertheless present many different natural conditions, there being among them y deep seas with a rapid current as well as snug little fjords with calm, shallow ters. It might be anticipated that these current-seas would offer favourable portunities for the exploration of the »Plancton« of the sea, and on the whole the exploration of everything that is carried along with and lives in the rapidly wing waters; for this reason, especially, the station was placed in the very rrent. I was able now, simply by hanging out »pelagic« bags by the side of ship, to let the current pass through these, and thus catch the organisms that e in the water. By this arrangement much time was saved, as it was unneces- y to sail about with the bags, and the latter might be left without inspection long as we wanted. It gave us the advantage also of the bags hanging out hing during the night, and this is the most favourable time, as many animals nnot avoid the bags in the darkness, as they would have been able to do in day time; moreover many species of animals, certainly, move about in the rface-water far oftener in the night than during the day, in consequence of nich, too, a greater number is caught. This is particularly applicable to *Gam- ridæ* and *Cumacea*, perhaps also to certain other *Crustacea* and a few *Annelidæ*, which I have been convinced, partly by comparing the catch of the day to at of the night, partly by lightening the surface of the water in calm nights by eans of a small electric lamp; shoals of *Gammaridæ*, for instance, are then seen arming about, which we do not observe in the day-time.

Owing to the great facilities for pelagic fishing, the latter has been carried so to speak every night from April 4.—November 11., 1891, when the Station as towed to Kolding, and from April 2.—September 1., 1892, when the Station t Fænø, and was towed to Svendborg Sound. The interval I have tried to fill by means of a few observations.

The contents of this pelagic fishing have been proved to change much cording to the seasons; I shall state it here for every month during the said time:

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1891.	Pelag. eggs of fishes.	Pelag. fry of fishes.	Larger young ones and full-grown fishes.	Medusæ.	Other things of interest
April.	[1] *Gadus callarias, Pleur. flesus, Motella.*	*Cottus, Agonus, Clupea, Gunellus.*	Cyclopterus, Pleur. limanda, Gobius sp. sp., Zoarces.	Sarsia tubulosa, other Hydromedusæ, Aurelia, Cyanea.	Nereids in breeding-dress
May.	Gadus callarias, Pl. flesus & limanda, Clupea sprattus, Motella.	*Cottus, Agonus, Clupea, Gunellus,* Liparis, Pleuronectes vulgaris, Gadus callarias.	Pl. limanda, Cyclopterus, Gobius, Zoarces, Syngnathus.	Pleurobrachia, Bolina, Idyia, Sarsia, Aurelia, Cyanea.	3 Clione limacina, Sagitta, *Diatomaceæ*
June.	Pleur. flesus & limanda, Motella.	*Clupea,* Gadus callarias, *Motella,* Pleuronectes sp., Ammodytes?, Belone.	Gobius.	Aurelia, Cyanea.	*Diatomaceæ*
July.	Pleur. limanda.	2 Rhombus lævis, *Motella,* Belone.	Spinachia, 1 Agonus, Gobius, Nerophis.	Ctenophora, Aurelia, Cyanea.	Larvæ of Palæmonida and Crangon, *Diatomaceæ*
August.	None.	1 Rhombus lævis, a few Gad. merlangus, 1 Clupea sprattus?.	Gobius, Gasterosteus.	Ctenophora, Hydromedusæ, Aurelia, Cyanea.	Appendicularia, *Diatomaceæ*
Septbr.	None.	Clupea harengus, 1 Liparis, 1 Motella, 1 Raniceps? 1 Gadus merlangus.	Gasterosteus, Syngnathus.	Hydromedusæ, Aurelia, Cyanea.	Larvæ of Palæmonidæ and Crangon, *Diatomaceæ*
Octbr.	None.	1 Raniceps? 1 Clupea.	Gobius, Spinachia.	Aurelia, Cyanea.	Sagitta, Larvæ of Crangon and Palæmonidæ, Protoventricosa, *Diatomaceæ*
Novbr.	None.	None.	Gobius.	Aurelia, Cyanea.	

[1] *Italics* mark »frequent occurrence«.

	Pelag. eggs of fishes.	Pelag. fry of fishes.	Larger young ones and full-grown fishes.	Medusæ.	Other things of interest.
1891. Decbr. 1892. January.	*Gadus callarias*, *Pleur. vulgaris*. An unknown species with oil globule.	Aphya, Agonus, Cottus, Clupea harengus.	Gobius.	None (?)	Sagitta.
February.	*Gadus callarias*, *Pleur. vulgaris*.	Cottus, Gunellus.	Zoarces pull. Gasterosteus.	None?	
March.	*Gadus callarias*, *Pleur. vulgaris*.	*Gunellus*, 2 Agonus, 1 Cottus, 1 Liparis, *Clupea harengus*.	?	Hydromedusæ, very small.	
April.	Pleur. vulgaris, *Pl. flesus*. Pl. limanda, Motella, *Gadus callarias*, *Clupea sprattus*, Raniceps?	*Agonus*, *Cottus*, *Liparis*, *Gunellus*, Ammodytes, Gadus callarias, Clupea harengus, 1 Pleuronectes sp.	Zoarces, Gobius, Gasterosteus, Syngnathus.	Pleurobrachia, Bolina, Sarsia, Aurelia.	Clione limacina.
May.	Pleur. flesus & limanda, Motella, Clupea sprattus, Gadus callarias.	Gunellus, Liparis, Gadus, Agonus, 1 Pleuronectes sp.	Siphonostoma, Zoarces, Anguilla, Spinachia, Gasterosteus, Pl. limanda.	Sarsia, Cyanea, Aurelia.	Clione limacina.
June.	*Pl. limanda*, Clupea sprattus, Motella, 1 species with oil globule.	A few Gadus callarias, *Motella*.		Ctenophora, Aurelia, Cyanea.	A few Diatomaceae.
July.	Pl. limanda, Clupea sprattus, Trigla, Raniceps.	Motella, Belone.		Ctenophora, Aurelia, Cyanea.	Larvæ of Palæmonidæ & Crangon. Some Diatomaceae.
August.	Pl. limanda rare, Clupea sprattus rare.	Motella, Belone, 2Rhombus lævis, Clupea, 1 Pleur. flesus?.	Cyclopterus, Gobius, Liparis.	Ctenophora, Aurelia, Cyanea.	Larvæ of Crangon, Proto ventricosa.

Besides the animals mentioned in this account, we have caught in pelagic bags a great many other animals of those which ordinarily live near bottom on its vegetation, such as *Gammaridæ, Cumacea, Mysidæ, Idothea, Unio* mostly *Nudibranchiata,* also *Rissoa, Hydrobia,* and *Akera;* moreover *Annelida* in swimming form (the breeding form); finally, the larvæ of a great number of the animals, and of some very diminutive beings, such as *Cladocera, Copepodæ,* an swarm of *Protozoa,* among which the *Peridineæ* occupied a prominent position. I have paid especial attention to the eggs and fry of fishes, and to such lar animals as may be easily observed in the water, for instance the *Medusæ.* the other hand I have not considered it necessary to enter into a closer study the rest, but collections of them have of course been kept. — Among the thi that struck me most by these researches, carried on as they were through suc long time, were the changes in the contents of the catches, in quality as wel in quantity, changes which are partly of a shorter, partly of a longer duration. T latter, *the changes of long duration,* are evidently dependent on the seasons, a of a periodical nature. These periods ($1^1/_2$ period in the table) are clearly sta in the table. It seems that such a period, as might be supposed, may be divi into 4 parts, *nearly* corresponding to the seasons on the land:

1) From the end of *December—March* is the winter-period with eggs *cod* and *plaice,* and little fry of the fishes that spawn in winter or autumn, *Co Agonus, Clupea harengus, Gunellus, Liparis. Aurelia* and *Cyanea* are found only small numbers at this time, as they die away at the beginning of the winter. T water is very clear, and contains, at any rate in the beginning of the peri much less plancton that at any other time of the year.

2) *April—June* is the spring-period with an overwhelming quantity of eg and fry of fishes: of eggs must be mentioned those of the *Cod* and the *Plaic* the beginning of the period, moreover, those of the *Pleur. flesus* and *liman Clupea sprattus,* and *Motella.* We might now imagine that the fry of cod a plaice must play a very prominent part among the pelagic fry, as the eggs we so frequent in the former period. This, however is not the case. We do find few young ones, certainly, but it is always the fry of *Clupea harengus, Cottus, Agon* and *Gunellus* which plays the principal part, consequently *the fry of such spec of fishes as deposit their eggs on the bottom, attached to the latter or to the vegetati*

In this period there are great numbers of *Ctenophora (Pleurobrachia, Idy* and *Bolina),* accompanied by *Sarsia tubulosa* and the young fry of *Aurelia a Cyanea; Clione limacina* has also been caught during this period, in both yea and in 1891 there were great numbers of *Diatomaceae (Rhizosolenia* and *Chætocer* in the water, which at this time of the year has lost its winter-clearness. Wheth there is really a very sharp boundary line between these two periods, I cann tell, the researches during the winter being, ufortunately, few in number, as t Biological Station for fear of ice did not dare to remain in the Fænø Sound throu the whole winter.

3) The third period, or the summer-period, lasts from *July—August,* b it is so closely connected with the fourth 4) or autumn, from *September into t first part of December,* that they cannot be accurately divided. In the beginni of the summer there are still eggs of fishes as *Clupea sprattus* and *Pleur. liman*

ometimes also *Trigla*, etc., moreover fry of *Belone*, a few *Rhombus lævis*, *Motella*, nd a few young *Gadoidæ* and *Pleuronectidæ;* but in autumn there are neither elagic eggs nor fry of these fishes in any greater number, only *young herrings* ccur frequently. In the beginning of this period the *Ctenophora* are seen now nd then. *Cyanea* and *Aurelia* are now full-grown, and at last die away. In ummer, moreover, there are a great many larvæ of *Annelida*, *Univalves*, and *Crustacea*, for instance *Palæmonidæ* and *Crangon*. A few species of Crustacea appear later in the year in the transition time between summer and autumn, for instance *Mysis oculata*, *Idotea entomon*, *Idotea ventricosa*, which at times are found in huge numbers at places where none of them are to be seen in spring. — (See *Sparre-Schneider:* Forplantningen og livsvarigheden hos Amphipoderne. Tromsø Museums Aarshefter. 14. 1891).

In the latter two periods the fry of the pelagic eggs of fishes, which in the previous period were so common, *Pleur. flesus* and *limanda* and *Clupea sprattus*, are not seen in great numbers neither; only larvæ of *Motella* may be said to be rather common.

It is one of the facts that have astonished me most during these researches, *that the fry of pelagic eggs, which were sometimes found in such huge numbers in Fæns Sound, was not hatched there or, at any rate, was only to be found there quite exceptionally.* Already in the first year I had been surprised at this, and I thought that it was probably owing to my fishing tackle — that my implements were too small, for instance. I used in 1891 bags with an opening of c. two feet in diameter; the following year a very long bag was constructed, with an opening of one fathom in diameter, but it caught only little else than the small bags. Nor is it likely, when we consider the matter closely, that the bag which can catch the pelagic fry of the non-pelagic eggs should not be able also to catch the fry of the pelagic eggs, if they were there in the same number, much the more so, as the fishing takes place in the night, on account of which the fry is not likely to see the bag and be able to avoid it; *no, I must think that the fry of almost all species of fishes with pelagic eggs, which occur in that sound, except Motella, are much rarer than the fry of those which deposit their eggs on the bottom.*

Though there was a difference between the two years as to the number of certain of the forms of those animals and plants which occurred in the plancton, the congruity between the period and the seasons is evident. Thus, in 1891, the quantity of *Diatomaceae* was quite enormous during the months of May—September, while in the whole of the year 1892 they only appeared in very small numbers. That there must have been a difference also in the quantity of eggs and fry in the said two years is evident from the fact that a quantity of tender fry of *Pleur. vulgaris* and *Pleur. flesus* was to be seen in 1891 on the sand along the shores of the Lesser Belt, while such was not found at all in the following year. In the main point, in the same returning of all other forms, there was however the closest agreement between the said two years.

The above-mentioned *changes of short duration*, on the other hand, are so irregular that we can neither speak of daily, weekly, nor monthly periods; they occur independent of all certain spaces of time. An example will serve to throw some light over these changes. In the days from the 13th—17th May 1892 we entered in the journal, with respect to our pelagic fishing, that nothing particular

was found in the bags, though a good, strong, southerly current ran through the there were found a few eggs of *Motella* and *Clupea sprattus*. The main direct of the current in those days had been southerly, the weather had been ca without any strong wind, and the salinity of the water was about $1_{,74}$ % (specific gravity c. $1_{,0145}$ with a temperature of c. 8° C.). On the 18th we got stiff northerly breeze and northerly current, so that the salinity rose to more th $2_{,00}$ % (the specific gravity between $1_{,0172}$—$1_{,0192}$; temperature $7_{,8}$—9° C.). For t 18th and 19th of May and the following days till the 26th of May the journal inform us that great numbers of eggs of *Pl. limanda*, *Cl. spratus*, and *Motella* were caug pelagically, perhaps also other species with oil globule, which however cannot further determined; moreover a number of *Ctenophora* were seen in the water; few small young ones of *Gadus (callarias?)*, and some few larvæ of *Pl. flesus* we caught during these days; large numbers of *garfish* were caught by the fisherme just at the same time. Already in the end of May, however, the salinity had su down to about the same as before the »period«, and in the pelagic bags we g now »scarcely anything of importance«; only a few eggs of *Clupea sprattus* a some *Copepoda* and *Cladocera* are mentioned.

I have observed many changes in the contents of the plancton like th which I have here described, of shorter or longer duration; it is clear that the changes are most conspicuous at the time when the eggs and fry of the fish particularly flourish, viz. spring and early summer; but such changes may al happen in August, for instance about the middle of this month in 1892, when fr of *herrings* and *flounders* suddenly appeared, as also a larger number of *Diatomace* than usual in that year; nor did the *Ctenophora* stay away.

What, now, is the cause of such changes of short duration? Whence d they come, the said fry of *Pleuronectidæ* and *Gadoidæ*, the eggs, and the *Cte phora*, etc.?

There can scarcely be any doubt that the water which carries the animals and plants along *comes from the Kattegat;* this is indicated by its hig salinity (see pag. 7), and by the fact that these »changes«, according to m observations, are often introduced by strong westerly and northerly winds, whic occasion a current from the north in the Lesser Belt. We might imagine that i was a very simple thing to prove this by observation of the current; but 1) th current in Fænø Sound, where the Station was situated, does not always run i the same direction as west of Fænø in the Belt properly so called; 2) there ca be a difference in the direction of the current at the surface and near th bottom; and 3) during such »changes« the current will pretty often vary; finall 4) it is not always clear to us when such a »change« commences; we do no observe it till we are in it.

I have therefore by no direct observations been able to prove that thes changes are occasioned by more water running in than out in the Belt; but b observing these things daily on the sea, I have arrived at the conviction that it is so. I myself, as everybody else who sails daily on these seas, have a very distinct notion of the main movement of the water, whether it has, in a given period, been northerly or southerly; and the animals that are characteristic fo such periods, for instance *the larval fishes,* many of *the eggs,* the *Ctenophora*, *Clio*

naeina, etc., indicate also that the water has come from the north and not from e Baltic Sea. I shall later on examine the question, whether such water may ı imagined to go through the Great Belt and then, turning westward, pass out rough the Lesser Belt; but, surely, it cannot be the rule. When I have several nes seen a salt stream coming from the south, and running for a few hours, I ıve therefore generally looked upon it as the returning salt water which now *rries back again the animals that belong to it, except those which have been destroyed being mixed with fresher water, and those whose pelagic life has just been finished those days in which the water has been here in the southern parts;* these latter ıes must of course remain. In this way, for instance, the eggs and fry of the aice are carried into the Lesser Belt, but it is another question whether they are rried in there at the very time when the pelagic life of the fry is at an end, d *on this it depends, evidently, whether there will be any growth of plaice at all in at year in these parts.* This happened in 1891 when there were found a great ımber both of *Pleur. vulgaris* and *Pleur. flesus* at the places fit for them on the ores of Fænø; but in 1892 no such fry was to be seen, with the exception rhaps of one single specimen.

On the whole that sort of little flat-fishes can scarcely be very common ere; for the fishermen who almost all the year round dig for worms at these ıces, declared positively that they are never found there; and it is quite sure at they are not so common as in the northmost Kattegat where I have seen ge numbers of them on quite shallow water — and where every fisherman ows them and their resorts.

The objection might be urged here that the *Pl. vulgaris* and the *Pl. flesus* ı at home in the western part of the Baltic Sea as well as in the Kattegat, and ıt their eggs, consequently, may be carried into the Lesser Belt with a southerly rrent just as well as with a northerly one; to this I can only answer that, as as we can see, the eggs actually come in greater numbers with a northerly ft only.

A few words on the hydrographical conditions may here be appropri- ly added.

It is well known that a great mass of water of low salinity, especially in ı spring and summer half-year, flows from the Baltic Sea through the Sound, ı Great Belt, and the Lesser Belt, water whose salinity may be estimated at out 1,5 %, never quite 2 %.

This outflow occasions an influx, in the opposite direction, of salt water ween 2—3 % (see for instance *O. Petterson* och *G Ekman:* Skageracks och Katte- s Hydrografi p. 140. Kong. Sv. Vet. Acad. Handl. vol. 24, Nr. II. 1891) which, ecially in the spring and summer half-year, is very salt and, consequently, must ep near the bottom under the outflowing current. This salt, heavy water comes m the deeper parts of the Skager Rack and goes down along the deep eastern ttegat, sending one branch into the *Sound, which, however, does not go through sea,* another branch northward of Zealand, which at Samsø branches off, one nch going through the *deep channels of the Great Belt and down into the western t of the Baltic Sea,* another northward of Funen into *the Lesser Belt,* through ich however it scarcely brings very considerable volumes of water of great

salinity. For while the salt under-current in the Samsø-Belt, on the deep, in 188
April and May, was $2_{,77}$—$2_{,97}$ %, and in the Langelands-Belt in the months
April and May 1886 $2_{,47}$ % and $2_{,78}$ %, it was in the southern part of the Les
Belt (Faaborg) in the same year in the months of April and May only $1_{,87}$ % a
$1_{,98}$ %. *The western part of the Baltic Sea, therefore, must certainly get its grea
supply of water of 2—3 %, if not all, through the Great Belt.* A glance at a cha
of the depths will easily convince us why it is so: the Lesser Belt is in son
places too low, in others too narrow, to permit such a current to go through
almost unmixed. In spite of this, however, the surface-waters of the Great Be
may be much fresher than those of the Lesser Belt, and generally they are so.

In the winter half-year matters are somewhat different, the outflow fro
the Baltic Sea on account of the atmospheric conditions (temperature, downpou
direction of the wind, etc.) being not so strong as in the summer half-year. Th
consequence of this is that *the surface-waters of the Skager Rack can enter mo
freely into our seas and make the latter more saline near the surface than in summe
time.* This »winter salt-water», Petterson's »Bank-vatten«, is supposed to com
from the shores of the Skager Rack, while the »summer salt-water« is of pur
oceanic origin, and both salter and warmer.

Petterson's representation of the hydrographical conditions seems to me t
be very acceptable, and I should not hesitate to apply it to our seas as a
explanation of the occurrence here of »the more pelagic« among the migratin
fishes, as the *mackerel,* the *garfish,* the *stingbull,* the *gurnard,* etc. Immigratio
into our sounds and belts in spring depends on the inflow into the Kattegat, an
perhaps farther down to the south, of certain oceanic waters, »the summer sal
waters«; that the fishes, when they have first got so far, may take it into the
heads to go still farther into the seas, nay even stray away far into the Baltic
is a matter of course. (See *Möbius* u. *Heincke:* »Die Fische der Ostsee«.) B
connecting these phenomena it will be possible, not only to explain the variou
yearly migration-phenomena of the said fishes, but it will to some degree b
explained also why these fishes do not every year in the same numbers and wit
the same intensity enter our seas. *For the causes of the said currents are, as it i
well known, the atmospheric conditions,* and in these there is also a certain *irregularit
or* perhaps *periods.* The series of observations are scarcely long enough as yet t
determine these, which must be supposed to last for several years.

That the hydrographical conditions have the very greatest influence o
the animal life in our seas is a given thing; and they influence, not only th
migrating fishes, but also those of our stationary fishes which have either pelagi
eggs or a fry that goes through a shorter or longer pelagic existence, as it is th
case, with very few exceptions (the eel?), with all our more variable species o
fishes. Eggs and fry will be seized by the waters, and *those having the highe
salinity being best able to bear them,* the tendency in our seas will be to remove th
eggs and fry from the shores where the water is fresher, and carry them awa
to the deeper and more open seas where the salinity is sufficiently high. Thi
agrees also with all actual observations abroad and at home: *shore-waters with
brackish water are unfit to afford dwelling-places for pelagic eggs and fry of fishes.*[1]

[1]) That our fresh-water fishes have no pelagic eggs has been known for a long time.

for are they fit dwelling-places, of course, for *pelagic fry of the lower animals* that equire a higher salinity, and we may expect, therefore, that *the currents will have great influence also on the distribution of these animals, though many of them cannot migrate when full-grown, such as the fishes are able to do.*

The seas where we may expect a great difference in the conditions in the arious years are, among others, those that connect the south-western part of the Kattegat with the western part of the Baltic, or the seas around Samsø together ith the Great and the Lesser Belt. Such differences have been observed in these arts, about which see *H. A. Meyer:* »Periodische Schwankungen des Salzgehaltes n Oberflächenwasser in der Ostsee und Nordsee. 4 Bericht der Commission zur issensch. Untersuchung der deutschen Meere im Kiel. Berlin 1874«, where the early average-salinity of surface-water is stated to be, for instance at Sønderborg n 1872 $2_{,06}$ %, 1873 $2_{,84}$ %, 1874 $2_{,06}$ %, and from 1875—81 $1_{,76}$ %—$1_{,82}$ %. n the same report, p. 64, *K. Møbius* mentions that, after the winter 1874, when he salinity was considerably diminished, he could not any more find *Echinus iliaris, Echinocyamus pusillus, Nassa reticulata, Ophioglypha albida, Akera bullata, Eolis Drummondii;* not till 1882, when the salinity rose, he found some of these nimals again, and he thinks it is the variations in the salitiny during the various ears, which have effected these changes in the fauna. — The only instance of imilar changes in the fauna I have been able to state is that Professor *Chr. Lütken* in 861 in the Lesser Belt at Strib, Middelfart, and Fænø, found *Echinocyamus pusillus,)phiopholis aculeata* (though not common), and *Eupagurus Bernhardus* in great numbers; ut I have been unable to find these three animals again there in 1891—92, hough my dredgings extended from Fænø as far as off Middelfart, and north of 'redericia as far as Endelave. I attach particular importance to *Eupagurus Bernardus,* for it was formerly common in Fænø-Sound, as Professor *Chr. Lütken* still listinctly remembers; the fishermen over there also know it; *but now it is not ound there any more.* In the occurrence of the lobster *(Homarus vulgaris)* there s, according to the statements of several persons, a similar variation in the Lesser Belt; but it is never common there, and in 1891—92 I heard nothing at all bout it. I only caught one single young lobster, about one inch long, in Fænø ound, in 1892.

Well, we say then that the salinity is the cause of the different distribution f these animals, but why? 1) Is it the lower salinity that *kills* the animals? — 2) Or do they lose the *power of propagating* so that the whole stock in the less aline years dies out for want of a growth of young animals — as certain oysters re said to do when they are fattened too much? — 3) Or is it the low salinity *hich does not permit the fry to pass through its pelagic stage?* — 4) Or, finally, is t southerly currents which, besides making the water fresher, *carry away all the ry* from these seas during breeding-time — after all, consequently, not the alinity *itself?*

It is not easy to answer these questions with certainty, but 3) is, I uppose, the commonest case; for *all the said animals* which are influenced by the ariations in the salinity *have a fry which is pelagic.* Such species are certainly ost exposed when the salinity is diminished; for if they have not a suitable alinity, *and that, moreover, in the very breeding-time,* they are done with. That, (as

in 4), not only the salinity of the water, but also the direction of the current, of importance, is a matter of course; but *the whole fry of a species will scarcely carried quite away* in this manner, even though the greater part of it may.

The influence of the salinity on the distribution of the eggs of fishes our seas is scarcely generally realized, but it is certainly not inconsiderable. I shall here say only that in 1891 there was a growth of young *Pleuronectidæ* at Fa but in 1892 there was none. This must surely be explained by a *favourable unfavourable direction of the currents in those days when a great number of the yo fish leave the pelagic stage and become shore-animals.* But here again we meet riddle: the litle pelagic young ones of *Pleur. vulgaris, Pleur. flesus* and *limanda* are know, carried about by the currents involuntarily or, in their later stages, also involuntarily; but when this stage is over, and they commence their life on bottom, then *Pleur. vulgaris and Pleur. flesus are found only in the immediate vici of the shores on a depth of a few feet,* while, on the other hand, *Pleur. limanda is found only on several fathoms of water,* up to c. 10 or more; here, consequent is a *remarkable distribution of the fry, different for the different species.* — It m be observed, however, that I have not yet succeeded in using any sort of fish tackle which is more particularly suitable for catching the very smallest stages the said flat-fishes *on deep water;* I cannot directly prove, therefore, that these l young ones of *Pleur. vulgaris* and *Pleur. flesus* (c. $^1/_2$—$1^1/_2$ inch) are not to be found deep water, nor have I been able to prove the existence there of the quite you *Pleur. limanda.* Of these very young fishes I know only that the little *Pleur. limanda* never found along the shores on shallow water, but that the quite young *Pleur. vulga* and *Pleur. flesus* are found there, even in great numbers, for on shallow water is easy to use suitable catchers with small meshes, etc. The fry, however, o 2 inches and more, is easily caught, even on deep water, as it has been prov that such fry of *Pleur. vulgaris* between 2 and 4 inches, is found only on very shal water at suitable, sandy places, especially in our most open and saline seas Kattegat, the Great Belt). Similar fry of *Pleur. flesus* is even more unwilling leave the shores; it enters the enclosed fjords and fresh waters connected with sea. *Fry of that size* (c. 2—4 inches) *of Pleur. vulgaris and Pleur. flesus is not found all in by far the greater part of the Belts and the Kattegat,* nor, according to Engl researches into this matter, is it to be found anywhere in the German Sea, o *within a narrow border along the shores of these seas,* so narrow that it can scarc be marked by a perceptible line on a common map without being too broad most places. The young *Pleur. limanda* of 1—2—3 inches, on the other hand, found in the deeper parts of our seas, but then again not on the shores.

How can we now imagine this distribution of the fry to have originated? Can it have arisen already with the eggs? — Scarcely. The eggs are distribu only according to the physical properties of the water, which, as above mention will remove them so much the farther away from the shores, the heavier the eg are; that they should sink to the bottom in the shallow and rather fresh wa near the shores, and there be developed in greater numbers seems improbable me and incompatible with the observations, which prove that the fry is not fou in our fresher, inclosed waters. Moreover, the eggs (as also *Hensen* supposes) wo soon be eaten when they lie on the bottom of our shallow seas with their r

ıimal life. — We must then, as a rule, suppose the eggs to be distributed :ording to their specific gravity, in such a way that they will be obliged to go much the farther out on sea, and on so much the deeper places, the heavier ey are — if the eggs are to be developed into young ones; and I suppose that is is a thing to which the fishes do pay attention when they select their breeding-aces. Those of *Pleur. vulgaris* are farthest out on the sea, the breeding-places of *'eur. flesus* and *limanda* not quite so far, yet at any rate outside the fresh and ackish waters where these fishes, out of the breeding-season, often go in. (See e report from Holbæk). The specific gravity of the eggs of *Pleur. limanda* ems now, according to my measurements, to be somewhat less than that of the gs of *Pleur. vulgaris, so that both this and the situation of the breeding-places should em to remove the eggs of the Pleur. vulgaris from the shores and bring nearer those Pleur. limanda: the contrary distribution of the fry is therefore doubly remarkable.*

I do not doubt that immense numbers of the eggs of these fishes, now id then at any rate, must be destroyed *by being carried so far away at sea that e fry is never able to reach the shore.* Perhaps the young fishes themselves, to me degree, are capable of looking out for shallow water; but if their pelagic istence is at an end at a time when they are far from land they must sink to e bottom, and if they cannot reach the shore till they have grown c. 2 inches long, ey must also be destroyed; for such fishes, two inches long, of the two said species, e not to be found on the deep, and of *Pleur. limanda* only down on depths of)—20 fathoms. I think it very unlikely, however, that these little delicate fishes ould travel along the bottom towards the shores; *I suppose that if the young hes do not end their pelagic existence over a suitable bottom, they are lost.* We can erefore expect only to find the tender fry of *Pleur. vulgaris* and *Pleur. flesus* in eater numbers at such places *where during the breeding-season (spring-time) rather lt water gets near the shore,* consequently not i our fjords or the shallow seas rrounding our little islands, but in the Kattegat, the Great Belt, north of Funen, c.; *and so the distribution is actually proved to be.* It is a matter of course that is distribution is different from year to year; it all depends on the currents that e prevalent during the breeding-season, indirectly, consequently, on the atmospheric nditions which produce these currents.

The atmospheric conditions then influence the distribution of the full-grown igrating fishes as well as the fry of all fishes that live a pelagic life at a certain age of their development — through this also the full-grown stationary ones. very practical fisherman knows how all fishing depends on the weather, and ffers in the different years, but the closer connection is rarely considered. Here have tried to discuss some other factors in order to elucidate the matter.

Pelagic eggs of fishes in the Lesser Belt 1891—92.

In order to give the reader an idea of what numbers of pelagic eggs found in the water at certain times, I shall mention that I caught about 5 eggs in a bag whose diameter is c. 2 feet, after it had been hanging out d the night of the 28th April 1892, though not by far so much water had through it, as would have run through a ring, 2 feet in diameter, with no behind it. The transverse section of that part of Fænø Sound where the rent is strong, is *at least* 15,000 times larger than the opening of the bag: whole mass of eggs, which in the rapid current that whirls up everything, from the very bottom, must be supposed to be equally distributed through whole volume of water, was consequently that night *at least* 15,000 . 50,000 = million eggs, besides all those that passed by west of Fænø in the Belt prop so called.

The eggs were caught during a southerly current, but the water was s and the current had been northerly during the preceding days. The station situated in such a way that, generally, we could fish with good profit only w the current came from the south; it was then, on their return to the Kattegat, that these eggs were caught, together with *Clione borealis* and a great number young fishes. — Such large quantities, however, were not caught very often. — T greater part that day consisted in the eggs of *Pleur. flesus*.

Those who have personally seen these multitudes of eggs will wond doubly that they cannot find even a somewhat corresponding number of young fi Altogether I did not, in 1891, see 20 detached little young ones of *Pleur. fles* though we tried in many ways to catch them; to hatch such onboard in gr numbers, on the other hand, was easy enough.

In spring huge numbers of full-grown *Pleur. flesus* which had spawn were found in Fænø Sound and at Middelfart, so that both weels and pound-n sometimes were almost filled with them. The waters here must therefore be look upon as the spawning place of *Pleur. flesus*. Towards summer it became m rarer at Fænø, but might now be caught in the Gamborg and Kolding Fjor Of the various species of *floating* eggs, found in Fænø Sound, the following ha been determined, partly by means of the foreign literature, partly by comparis with the spawn of the ripe fishes:

1. *Gadus callarias*, in great numbers.
2. *Motella sp.*, found often, but never in shoals.
3. *Raniceps raninus?*, only very few eggs; the eggs of this fish have ne been described, and are scarcely recognised when taken out of the fis the determination is only a supposition.

4. *Pleuronectes vulgaris,* in great numbers.
5. — *flesus* — —
6. — *limanda* — —
7. *Rhombus?*, a few specimens.
8. *Clupea sprattus*, in great numbers.
9. *Trigla sp.,* some few times, and not in great numbers.

Besides these eggs a few others have been observed, though rarely, and e have not been able to determine them. They were so few in number that ıeir character could scarcely be settled; I shall mention, however, that some of them ad coloured oil-globules.

Of eggs deposited on the bottom were found:

1. *Cottus sp.*
2. *Agonus cataphractus.*
3. *Gobius niger.*
4. — *microps.*
5. — *minutus.*
6. — *Ruthensparri.*
7. *Liparis sp.*
8. *Spinachia vulgaris.*

'he eggs of *Cottus* and *Agonus* were found only one single time, of the latter a ımp that had drifted ashore.

If we compare these two lists with the list of the commonest pelagic young shes (p. 4), we shall see that the fry mentioned in the first series (the fry of ıe floating eggs) is very rare, the *Motella fry*, only, being found pretty often, lthough in little numbers. The young ones of the second series, on the other and, were rather common and were caught in great numbers, and besides the pecies mentioned in this list was found also the fry of *Centronotus, Belone,* and *'l. harengus,* in great numbers, which all deposit their eggs on the bottom of the ea. That the eggs of *Syngnathidæ* and *Zoarces* could be gathered in as great num- ers as might be wished, is a matter of course.

The reason why fry of those fishes whose eggs are attached to the bottom ıay be fished in such great numbers, and so constantly, is partly that the fry of everal of these species has no real pelagic (floating) existence, as the young ishes, on coming out of the eggs, remain among the plants, so that they are ıot caught by the currents and carried involuntarily along with these in the lear water. That the fry of *Syngnathidæ* and *Zoarces* immediately commences living t the samme places as the full-grown fish, has long been known; but the various pecies of the genus *Gobius,* as well as *Spinachia,* and *Gasterosteus,* do the same, o that their fry, though not *creeping* about on the bottom like the fry of the ther two, is rarely to be caught in the pelagic bags, and must be taken in another vay among the zostera leaves, where they may be caught in huge numbers. Because, then, the fry of these species remains at the place, it is easy to get it there in reat numbers. This, as I have said, is the case with the four *Gobii* and with he *Spinachia,* among the above-mentioned eight species, and these, therefore, nust be looked upon as *local* species of fishes, *stationary fishes in the strictest sense of the word*, like the *Zoarces* and the *Syngnathidæ*. The other species whose eggs

are also deposited on the bottom, and whose fry was common in Fænø Sound, hav
all a pelagic stage, viz. *Cottus, Liparis, Clupea, Belone,* just as the young ones o
the pelagic eggs of fishes have: but when these pelagic young ones of the speci
of fishes with attached eggs, in contradistinction to the young ones out of th
pelagic eggs, were so very common in Fænø Sound, the reason must be that it's
the tendency of the current to carry everything that is pelagic away from Fænø; an
*it can remove the pelagic eggs before they are hatched, but the young ones fro
attached eggs of course not till they are hatched and go through a pelagic stag*
— We might expect, therefore, to find proportionally few more advanced one
of such fishes with a pelagic stage, such as *Cottus, Agonus, Centronotus, Clupea
Belone, etc.*, and this also proves to be the case with respect to *Cottus, Centronot*
and *Agonus; the young ones of these 3 genera are, after their pelagic stage, very ra*
in Fænø Sound, as they were also in Holbæk, where scarcely any younger, n
scarcely any half-grown specimens were found. On the other hand the young one
for instance of *Cottus,* seem to be rather common in the *Kattegat*, at the stag
which follows the pelagic period. — When I have seen pretty many young one
considerable size, of *Clupea* as well as of *Belone*, the reason is, perhaps, *that thes
species, as it were, never get out of the pelagic stage*; when they have reached
certain size they are, on account of their great power of swimming, to a muc
higher degree independent of distance than are the young *Cotti*, which live ne
the bottom, and they get back sooner, therefore (consequently younger
and smaller) to shores and fjords, from which the current and the salinit
have driven them away in their very first, tender period.

The species of fishes I have observed in the Lesser Belt, in 1891—9
are as follows.

	Eggs.	Pel. young ones.	More advanced young ones.	All ages.	Full-grown
1. Scomber scomber ×[1])					×
2. Cottus scorpius ×)	×	×	Some few.		×
3. — bubalis ×)					×
4. Trigla gurnardus	×	×			
5. Agonus cataphractus ×.....	×	×	Some few.		×
6. Gobius niger ×.....	×			×	×
7. — microps ×	×			×	×
8. — minutus ×	×			×	×
9. — Ruthensparri ×.....	×			×	×
10. Aphya pellucida.....		×			
11. Liparis	×	×	×		×
12. Cyclopterus lumpus			×		×?
13. Anarrhichas lupus.....			1		1
14. Lumpenus islandicus					×
15. Centronotus gunellus ×		×	Some few.		×
16. Zoarces viviparus ×			×	×	×

[1]) Those marked × in this column are very common in the Lesser Belt.

	Eggs.	Pel. young ones.	More advanced young ones.	All ages.	Full-grown.
17. Spinachia vulgaris ×	×		×	×	×
18. Gasterosteus pungitius × ...			×	×	×
19. — aculeatus × ...			×	×	×
20. Belone vulgaris ×		×	×		×
21. Crenilabrus melops					×
22. Ctenolabrus rupestris ×					×
23. Gadus callarias ×	×	×	×	×	×
24. — merlangus ×			×		×
25. Motella cimbria	×	×			×
26. Raniceps raninus	× ?		1		×
27. Ammodytes ×		×	×		×
28. Drepanopsetta platessoides ..					×
29. Rhombus maximus			×		
30. — lævis	?	×			
31. Pleuronectes vulgaris ×	×	×	Some few.	×	×
32. — flesus ×	×	×	Some few.	×	×
33. — limanda ×	×	×	Some few.	×	×
34. Solea vulgaris					×
35. Orthagoriscus mola					×
36. Siphonostoma typhle ×	×		×	×	×
37. Nerophis ophidion ×	×		×	×	×
38. Salmo salar					×
39. — trutta ×					×
40. Clupea harengus ×		×			×
41. — sprattus ×	×	×			×
42. Anguilla vulgaris			×		×
43. (Conger vulgaris)					×
44. Acanthias vulgaris					×

By comparison with the list of the fishes in Holbæk Fjord the two districts ill be found to hold many in common; all the stationary and fjord fishes at olbæk, for instance, are represented in the seas of the Lesser Belt, the *Zoarces,* ie *needle-fishes, sticklebacks,* the *Spinachia vulgaris*, and all four *Gobii*; of these ur, certainly, two only really belonged to Holbæk, the two others being fond of ie clear, streaming waters of the Lesser Belt *(G. Ruthensparri* and *minutus);* this perhaps also the reason why *Liparis* is found in the Lesser Belt but not in olbæk Fjord, and why *Agonus cataphractus* and *Centronotus gunellus* are more mmon there. That the *plaice, common dab,* and *cod* are common in the Lesser elt is certainly also to some degree owing to the brisk and, in summer-time, ol waters here; perhaps also the depth of the sea is of some importance to the *aice* and *common dab.*

When, on the other hand, the *sole* is much rarer in the Lesser Belt, the ason evidently is only the long distance between this sea and the deep eastern attegat, the favourite dwelling-place of the *sole* in our waters. That *the migrating !, or silver eel,* is so common is owing to the connection which the Belt forms tween the western part of the Baltic Sea and the Kattegat, while the Issefjord s only the silver eels which yearly grow up, out of its own stock of *yellow eels.*

The common dab (Pleur. limanda).

I shall now try to show some facts connected with the occurrence of *Pleur. limanda* in its various ages, in the seas around Fænø as well as in the other seas I have had the opportunity to explore.

As I have mentioned before, the eggs of *Pleur. limanda* were found in great numbers, floating in the sea at Fænø, at certain times; they were found also in our other seas towards the north; but the *little, newly hatched young ones* have scarcely seen except when hatched on board. The smallest specimens of *Pleur. limanda* I have been able to catch in nature, are (perhaps with the exception of some few indeterminable pelagic young ones) at least $1^1/_4$ inch long, and of these, which now live near the bottom, I have been able te get only some few ones. Not till the *Pleur. limanda* is 2 inches long (or more), has it been possible for me to catch it in greater numbers, in seines especially adapted for this purpose, but I hope next year to be able to catch also the smaller fry. The seine could fish all sizes from 2 inches and upwards. In table 1 I have given the contents of some of these draughts.

In the *first column* of this table are shown some young specimens of *Pleur. limanda* from Hirtsholmene, March 1892; they are represented by groups of two sizes, both of males and of females; one is from c. 6—$3^1/_2$ inches, the other from $3^1/_2$—$1^3/_4$ inch. Full-grown ones (which, we know, will spawn in April, May, and June) were scarcely found among these, which therefore must be looked upon as young, unripe specimens, of two different annual series (1st and 2nd). In the columns farther to the right will be found, from the month of April from Fænø and from the month of June from the cove of Aalborg, sexually ripe specimens of sizes between c. $6^3/_4$—12 inches, representing the full-grown *Pleur. limanda*. In the cove of Aalborg, on the 27th of June, this series only was caught, which therefore, seems at some places to live separated from the two younger series.

In the *second column* we find *Pleur. limanda* from S. E. of Marthas-Fænø from the 22nd of June 1892, also representing the two smallest annual series. We are now in the midst of the spawning-season but find none or only one single spawning specimen among these. Both series have grown a little; in the 3rd and 4th column, from September and November, they have both grown so much that the largest specimens have reached the group of full-grown ones, and the sexual organs of those from the Skaw show plainly that. they are to spawn in the coming season.

At the bottom of the *third column,* from Lundeborg by the Great Belt, I find a specimen of $1^1/_4$ inch. I imagine that it was born 1892 and is c. 4 months old, but that its brothers and sisters have been somewhat smaller than itself, and have also been quicker perhaps to get out of the meshes of the fishing-nets. I must suppose, therefore, that the annual series to which this specimen belongs in the spring 1893 will be of the same size as the little specimens in column 1, or from c. $1^3/_4$—$3^1/_2$ inches, a few of them perhaps somewhat smaller. The latter hypothesis is strengthened perhaps by our finding two or three little specimens of *Pleur. limanda,* at Fænø, April 92 (see column 5), as these must be at least one year old.

the first four columns of table 1 we see the annual series from March
: 1892, and by comparing in our thoughts the future result from No-
2—March 1893 we shall see that the greater part of the growth takes
g the summer, nay my experience from the plaice suggests even that
is quite stopped from December—March.
en I have not arranged the other columns chronologically between
it is in order to leave the picture they give undisturbed. By a close
with the later columns from the Kattegat it will be seen, however, that
with them and form a direct supplement to them, the two youngest
es of them all, only, being feebly, or not at all, represented. By Fænø
hat different, the oldest series but one being abundantly represented;
ıt so distinct from the »full-grown« ones as usual. This seems to be
.e of the seas by Fænø; for it is seen also with respect to other species
at the yearly series there, though visibly distinct from one another,
however, than usual. I suppose the reason is, simply, that the seas
ıø are not the proper dwelling-place for any distinct race of fishes, but
ıere races of fishes meet from the north and the south as well as from
ıuring fjords.
.s a matter of course that the different seas with their different natural
end to efface the marked distinctions between the annual series which
nixed race would present. Explorations like these, therefore, ought to
on at places where such an intermixture does not occur; but these
ound only in the open seas from which I have hitherto been almost

curious thing will be observed in the columns from the Lesser Belt,
ıe youngest annual series of *Pleur. limanda*, which is so immensely
ıı the seas around Samsø, in spring-time is quite missing in the Lesser
s fjords; in the month of June, however, a few specimens seem to
down there.
ıt this is the direct result of the hydrographic conditions in the Belt,
ve described above, I must, most positively, assert. When there are
of the *Pleur. limanda*, of c. 3 inches, around Samsø and in the Great
ext to none in the Lesser Belt, it can scarcely be explained without
hat eggs and fry have been driven away from this place, before they
l the pelagic stage.
s mentioned above that the young ones of the *Pleur. limanda*, after
stage, live on deeper water than those of the *Pleur. flesus* or *vulgaris*,
ıey are never seen near the sea-shore. This is the very reason why
easier for me to gather suitable materials of all ages of this species
other; for this causes the younger ones to live at about *the same*
e somewhat older specimens of the *Pleur. limanda*, though (as will be
the tables) the full-grown ones are often seen alone. This makes it
to gather a large number of all sizes; the smallest specimens of *Pleur.*
d *flesus*, on the other hand, must be looked for at one place, the
at another, and the older ones again somewhere else; this demands
hing and much sailing about. Of the two last mentioned species I shall

therefore say only that they to seem, as a rule, to be 3 years in attaining sexual ripeness, but both, especially the plaice, grow much in the years following. — Also *Pleur. limanda* grows after having reached sexual ripeness, and can in the Lesser Belt reach the length of 14 inches, while the females, *generally,* are sexually ripe when about 8—9 inches long (some already when 6—7 inches), and the males generally when they are about 7—8 inches (some already when 5—6). In the Kattegat I have not caught such large specimens of *Pleur. limanda* as those I have found farther towards the south, the reason of which is, I suppose, that the seine in the Kattegat, *though not intended for this purpose,* have *fished great numbers of the Pleur. limanda,* and killed this not very strong fish, so that the large (old) ones have become less numerous than before. Something like this has happened also with the plaice, but I shall return to that more explicitly in a following essay.

The *Pleur. limanda* seems to reach about the same size in all our seas east of the Skaw as far as Bornholm. With respect to this fish, therefore, it would be easy to fix a minimum size for the whole country, but, partly, it is of little moment as a commodity, except at a few places, as for instance at Kolding, and not at all as an article of export, partly, its vital power is so slight that it is unadvisable to protect this fish by any *prohibitions* against the *landing* of undersized specimens.

The flounder (Pleur. flesus).

A glance at table 2 will soon inform us that full-grown specimens of *Pleur. flesus* are found in great numbers at *Fænø,* and that they breed there in March—May; on the other hand there are very few younger ones, under c. 8—9 inches, at the isle of *Fænø* itself, with exception of the tender fry in 1891 (see column 12). But at *Svendborg* there is something which resembles the topmost part of a younger annual series, and it has always returned by the many measurements I have undertaken there. If we count the neighbouring *Lundeborg* together with Svendborg, we get even another little annual series, evidently c. 1 year old, consisting of specimens just migrating into the rivulet there which flows into the Great Belt. At *Hadsund,* in *Kolding Fjord,* within *Trekroner,* consequently in closed, muddy seas, it is, on the whole, that the few middle-sized specimens of *Pleur. flesus* which I have seen (Comp. The Report of the Biol. Station from Holbæk Fjord 1890) have been caught; otherwise the space between the *little specimens* which are so easily found on the open seashore, especially where fresh water is flowing into the sea, and the sexually ripe ones, is so little filled up that I, so to speak, miss a whole annual series of these fishes: the second (middle) series. The table shows what has been found of it; its scarcity of specimens is striking compared with the second series of the *Pleur. limanda.* Might it be possible that the second annual series of *Pleur. flesus* for a great part lives in brackish or fresh water, as the eel does during a certain part of its life?

This deserves to be further explored. That *Pleur. flesus* is no genuine

ea fish is evident; for although it may be common in the Kattegat on deep ater, *it is so in the breeding-season only*, in early spring consequently, when fresh nd brackish waters are often frozen. — It would be interesting to get some closer nformation of *Pleur. flesus* with respect to its life in fresh water; that it cannot reed there with its pelagic eggs must be looked upon as a matter of course, I uppose, and its fresh-water period, if it is voluntary, would therefore be a perfect arallel to that of the eel, whose life would then no longer be quite unique.

According to the information given me by the Captain of the »Hauch«, he *Pleur. flesus* at Bornholm does not seem to be in any perceptible degree maller than it is in our other seas, so that a minimum size for the whole country ight be fixed upon also with respect to this fish. As *Pleur. flesus* is but of ocal interest however, such a fixed size would *generally* be more of a nuisance han a help. At those few places where it plays a greater part, it may be protected y special by-laws. At such places I should consider a length of 10—11 inches uitable for this fish; for though it commences its sexual ripeness at c. 7 inches, ts middle size is certainly considerably above that. Its vital power would be no indrance for such a protection: so tenacious of life as the plaice it is not fter all.

The cod (Gadus callarias).

Respecting our investigations into the age and growth of the cod I shall mmediately call the attention to the practical side of the matter — the *fishing* of ie cod. As appears from the preceding chapters, the object of these researches s to procure specimens of the fish in question, in all the sizes that are to be ound in the seas we explore. The fishermen therefore are generally unable to elp me, as they only fish the larger specimens; the Biological Station is obliged o fish for itself. This task is proportionally easy with respect to the flat-fishes, ut far more difficult with respect to the cod. In order to catch these I ave been obliged to use weels as well as seines (and hooks), and such as ere especially adapted for this purpose by their small meshes. From this eason it has scarcely been possible to do anything on quick voyages by the teamers, and I am exclusively limited to our researches from Fænø and Svend-org. These are represented in table 3.

It will be seen from this that the measurements in 1891 and 1892, from pring, agree very well together, viz. one annual series from c. 4—9 inches and nother from c. 10—15. In 1891, moreover, *the fry of the year* occurs in July—ctober, but *this fry of the year* is almost quite missing in 1892, like the fry of the ounder-fishes (see *ante*).

Easy as it may be, to distinguish between these groups in spring, is somewhat more difficult in autumn; for the difference disappears as the shes grow older, and a great number of cods, moreover, evidently immigrate into ese waters during autumn, of a size from 10—15 inches as well as bigger nes, up to even 34 inches. That this must disturb our table is easily understood.

As yet, therefore, I can say nothing with respect to the age and growth of the cod with certainty, except that cods one year old (in spring consequently) are from c. $3^1/_4$—c. 9 inches long, and that cods two years of age are from c. 9—c. 15 inches long; the three years old ones have as yet been so scarce that I can say nothing about them with certainty.

When we compare column 2 and 3, we might be tempted to believe that the many sexually ripe specimens of 13—15 inches perhaps represent the smaller specimens of the third annual series, which during the summer almost quite leave Fænø Sound; whether this may be the right view on the matter cannot as yet be settled. It is difficult to say with certainty where the three years old cods, together with those that are still older, live in summer; some few ones are found in the Lesser Belt at this time, but the greater number are somewhere else, and I really do not know any place where large cods may be caught in greater numbers during the summer till we are off the Skaw on the slopes of the deep Norwegian channel, where the Swedes in summer carry on bank-fishery. In the deep, eastern Kattegat, to be sure, there are large cods in summer, but it is scarcely the main body we find here.

Indeed it is a very difficult question, that of the races and dwelling-places of the cod; we know as yet so very little about it. To be sure, we know that little cods are living on our shores all the year round, but whether these be all of them, *fry of the large cods that live in open seas,* and become such themselves if permitted by the fishermen to grow up, is a question which is not easily answered; yet I am most inclined to think so with respect to our own shores. That the conditions of the Baltic Sea, perhaps, are different, shall not detain us here. As long as we cannot clear up such important questions, it is difficult to say whether the cod ought to be protected or not. — I shall mention here that the fishermen often say, that the cod is limited to certain places. They tell us that, at certain places, it has certain, easily distinguishable colours, and that it must *therefore* be a not migrating fish as these places are situated near one another. Everybody who knows the facility with which fishes change colour and generally adapt their outer appearance to suit the surroundings, will pay no regard to such statements. I have myself several times onboard made a grey cod turn light red, by keeping it for some hours in perfect darkness; and to make such a red cod grey again in a few seconds is still easier. When we have ourselves made that sort of experiments, we are not inclined to believe in colours as characteristic marks, by which we can distinguish between the various races of cods; but we understand very well why the cods at certain places have always a certain predominating colour. To say that there is not at all races of cod for which certain colours are characteristic, is again another thing; but we know as yet very little of these matters. The large yellowish-grey or brownish-grey cod, which in summer is found singly in our seas, is certainly also in its form different from those more longish ones with light grey back and white belly which in autumn and winter seem to follow shoals of herrings into our seas.

At Svendborg I found scarcely any cod under 9 inches; the younger ones seem therefore, like the flat-fishes, to spend much time in migrating from the open seas into the sounds and belts between the little islands. In the Kattegat

as far north as the Skaw, on the other hand, I have often found specimens between one and two years, oftenest in the zostera region. They never occur on the open sand-banks where the fry of the plaice likes to live.

As mentioned above the cod breeds in the Lesser Belt, but only rarely in the very Fænø Sound, more frequently in the expansion of the belt south of Fænø. The eggs were found in great numbers at the times when the water was most saline. It is remarkable that *Dannevig* at *Arendal* demands a salinity of c. $2_{,67}$ % for the eggs of the cod, if they are to float; *Hensen* at *Kiel*, on the other hand, only c. $1_{,8}$ %; according to my observations the eggs caught at Fænø would not float in less than $2_{,10}$ %. — Is the specific gravity of the eggs of the cod really so different at the different places?

Pelagic young cods were generally found in small numbers only, in the Lesser Belt, and I saw nothing of them under the *Medusæ*, where *G. O. Sars* tells ut that they live. On the other hand I caught a few young whitings under *Cyanea*. That I did not find young cods in greater numbers under the *Medusæ* is no wonder, however; they were like most other pelagic young ones too rare in the Belt.

After all, the cod belongs to those species of fishes which as a whole can scarcely be diminished in number by man, except perhaps in certain very narrow waters, for instance some of our own sounds and belts between the little islands. It will be hard to protect the cod by forbidding to carry the codlings ashore, as they will easily be killed when caught, for instance on lines. In a few little seas where they are taken chiefly in weels, it might be done perhaps; but in the Kattegat such regulations would certainly be useless, or they might actually do great harm.

The eel (Anguilla vulgaris).

When we compare the measurements of eels from the seas at the Lesser Belt and Svendborg, represented in table 4, with those in the Report from the Biological Station I, from Holbæk, it will be seen that the females everywhere are more frequent than the males, and much larger. As it has hitherto been impossible to catch a sufficiently large number of all sizes of eels, and as it is, moreover, very difficult to distinguish between the sexes of the younger specimens, I can, with respect to the age of the eel only refer to the earlier report.

As will be seen, there is a remarkable difference between the eels caught in weels at Holbæk, and those from Fænø and Svendborg. The eels at the two latter places agree very well with regard to size and appearance; they are all *Silver Eels*, i. e. eels in their breeding-dress; many of those from Holbæk, on the other hand, were not of this genuine migrating form, especially the younger ones — *therefore* the great difference in size. For I suppose that the eel *on an average* will be of the same size when it gets its breeding-dress, in all our seas both salt and fresh, and that the *smallest* females and males at this period as a rule are, respectively, c. 18 inches and c. 15 inches. It will be interesting to have these matters more closely examined; both theoretically and practically it is of

great interest, for no fish is so tenacious of life, and therefore so easily protected as the eel, without complicated legal provisions, only be means of a minimum size. If the silver eel has the same size everywhere, a fixed size for the whole country would further facilitate this matter. There is however one difficulty, viz that certain spearing implements and hooks kill the eel when they catch it, and they cannot, therefore, spare the little ones they happen to meet; but these matters might be arranged, I suppose. If so, the only thing would be to find a suitable size for such eels as might be caught. To settle this is not quite easy however, because there is such a great difference between the two sexes (cp. the tables), and while evidently c. 18 inches will be the most suitable size for the females, it must not be more than c. 14 inches for the males. As it is the generally accepted opinion that the eels leave our seas, in order never to return, shortly after they have got their breeding-dress, we aught — theoretically — to be permitted to catch *every genuine silver eel* but *no yellow eel at all.* There are however certain yellow eels which *perhaps* never migrate (and never breed); they certainly ought to be taken also. Moreover, it would scarcely be possible to catch eels enough in the sea, if it were only permitted to catch silver eels. There is no doubt then that it ought to be allowed to catch yellow eels. But with respect to these it might be defended perhaps to fix a size which in some measure fitted the females, for instance 16—18 inches. For the females are the more numerous by far in nearly all our seas, and those that give by far the greater profit. With such a size certainly, scarcely any males would be caught, but to make up for this it might be permitted *to catch all sizes of genuine silver eels.*

The fishermen, we know, distinguish emphatically between the two forms of eels, the *yellow* eels and the *silver* ones, and they maintain that they have nothing at all to do with each other, so rare are the intermediate forms in practical life; and the fishmongers who for many years have sold great quantities of eels insist on these two forms of eels being quite different fishes. Now this has certainly been proved to be wrong, and I have this year repeatedly onboard the Biological Station seen yellow eels become silver eels when they have lived some time (some weeks) in a pond; but it is quite possible that it might be done — practically — to treat them as two different species of fishes. By so doing much would be won; without losing anything (the males), we might agree on a suitable size for saleable eels, which would give a greater profit out of the fishery and protect the stock of fish better than hitherto, where, from the above-mentioned reasons, we have not dared to fix the minimum size above 14 inches. This size already, will prevent us in catching the smallest silver males; yet it must be added, that those under 14 inches are very rare.

I shall propose then to take into further consideration, if it would not be practical to forbid the sale of yellow eels under 16—18 inches, but on the other hand permit the sale of all sizes of silver eels.

In order to give some idea of the eels which are most frequently caught by the eel-seines in the Lesser Belt, I shall refer to the two first columns of table 4. It is seen what a small part the males play here. But it is not so everywhere. I have, however, not the necessary information of this to be able to give more general rules. Respecting the eel's dwelling places in our seas at the

various stages of its life I shall here state only, that the smallest eels are caught farthest up the fjords where the water is unclear and the bottom muddy with zostera; the fresher the water is, and the deeper, the larger are the eels. Yet there are many exceptions from that. — The eggs of the eel are not known in ripe state, nor the quite little ones, *at least not in our country;* I never saw them smaller than c. $2^1/_2$ inches. Such small young ones do not even seem to occur in the eastern part of the Baltic; the shortest that have been known here are 3—5 inches, consequently, as I suppose, one year older than our smallest. (See with respect to this question the paper I laid before the fishery congress in Gothenburg (at the General Meeting of Agriculturists 1891), and Dr. Trybom's communications in »Circular I. 1891, des deutchen Fischerei-Vereins«, p. 30). The farther we go from the open, salt sea, the larger are the smallest, known young eels. From Italy we hear about some much smaller ones, than those we have mentioned here (See *L. Jacoby*: Der Fischfang in der Lagune von Comacchio 1880, p. 61), viz. only 6—8 mm. The correctness of this statement, I am sorry to say, I have been unable to control; but so little eels are not known in the north, and if the fishes mentioned in the said work really are eels, what, after all, we can scarcely be permitted to doubt, then the breeding-places of the eel must be considerably nearer land in the Mediterranean than they are here.

Aphya pellucida (Nardo.)

On the 2. of October, after a very strong gale, I caught at Holbæk a young *Gobiid*, about 22 mm. long, which in Report I for 1890 in a foot-note p. 183 I referred to the *Genus Aphya*. A little later in October another one was caught, also after a strong gale. — In the winter 1891—92 one of the men caught an *Aphya* in Fænø Sound, c. 23 mm. long.

This fish was found in the winter 1888 (Nov. & Dec.) near Strømstad, among herrings, where, however, it is called rare (*H. Malm:* »Berättelse öfver Götheborgs och Bohusläns hafsfiskeri 1888—89«. In »Bihang till Hushållnings-sälskapets qvartalsskrift«).

Hitherto it has not been known in Danish seas, and it must be supposed that only now and then it is driven down here from the Skager Rack where it is common enough along the shores.

Spinachia vulgaris.

While the Biological Station was situated in Holbæk Fjord 1890, I made the following notes in the diary about the *Spinachia vulgaris*.

»26. May 1890. The *Spinachia* is breeding now outside the fjord and places its spawn on the poundnets in nests; it is easily caught in eel-seines in the fjord.

12. July 1890. The *Spinachia* has not been seen at all for rather a long while.

29. July 1890. Specimens of *Spinachia* of $3^3/_4$ inches seen singly. Young ones from this year, I wonder? — The older ones are quite disappeared.

25. August 1890. Caught 5 *Spinachia* of 5, $4^1/_2$, $4^1/_2$, 4, $3^1/_2$ inches, in eel-seines in Holbæk Fjord. — How long the big ones were, which I caught in spring, I have not noted down, but I am sure they were larger. These 5 must be looked upon as young ones from this year.«

I did not then pay much attention to the fact that the full-grown specimens quite disappeared all at once. It is a not uncommon phenomenon among the fishes that one species goes into a Fjord at certain times of the year, and out again at other times. Not till the following year, in the Lesser Belt, did I enter into a closer study of this matter. — Here, in early spring 1891, it swarmed with *Spinachia* which could be caught in great numbers in the deeper zostera region. But still in April they had not come quite near land; this did not happen till a little later, so that I on the 2nd of May 1891 discovered the first fishes building their nests on 1—2 feet of water. In the course of May and June a great number of nests were built on the sea-shores, and nearly by all attached *Fucus vesiculosus* bushes the large full-grown *Spinachiæ* of 5—7 inches where seen swimming about. Also onboard, in the pond (tank), in the Biological Station, the fishes we caught built their nests at this time, so that we had a splendid opportunity to watch the fish closely during this remarkable process. — In the beginning of July, on the 2nd already, I observed the young ones, about an inch long, which had now consequently got out of the nests; *and from this time the full-grown ones were quite rare.* The few specimens that had gone onboard in the pond, I remember to have seen at last lying dead on the bottom, without being able to state the cause of their death more exactly, and without being surprised at it, on the whole, at that time. But the longer I searched in vain for the full-grown *Spinachia* at those places where I had formerly found them in numbers, the more was I struck with their disappearance. They had not *quite* disappeared, certainly, in the month of July, for they were so rare that it was now harder for me to get hold of 2 specimens than formerly to catch 1000, and these single specimens were nearly always females which from some reason had been unable to lay their eggs, consequently sick specimens. It was possible however that they might have gone away from these seas to other parts where I could not follow them, and I determined therefore to see what would become of the young ones, whether perhaps they would go away to the same place as their parents, when they grew a little bigger. But they did not do so; *they remained in the same sea all the winter through,* and *had in spring the same size as the parents last year.* In other words: they are only one year in attaining their full growth and become sexually ripe.

In the course of 1892 a great number of *Spinachiæ* were examined at Fænø and at Svendborg, and table 5 gives a survey of the appearance of the whole stock from spring till autumn. In the first column are females and males full-grown, and caught in June; in the beginning of August these have all disappeared, and the young ones are 1—3 inches long. The last columns show how these are growing, respectively at Fænø and at Svendborg, till in the begin

ning of November they are of the same size as the full-grown ones were in spring.

If we now fancied that there existed full-grown *Spinachiæ* two years old and more, it would be necessary to look for them somewhere else than in the Zostera region along our shores, and they must then live I) either on the deeper Algæ bottom or II) on the bottom which is quite destitute of vegetation, on deep water, or III) they must live purely pelagically. The last mentioned hypothesis would scarcely be maintained in earnest by any zoologist. At various times I have had the opportunity to exploret he deeper parts of our seas with seines with little meshes, especially adapted for catching *Spinachia*, without finding such a stock, and I dare say, positively, that such a stock cannot live there or I must have found it. Yet there was still one possibility: that these fishes migh have hid themselves at places where they could not be found; they might have gone into the bottom as the eel does in wintertime; but in the first place they must have done so then in the midst of the hottest season, just the reverse of what our other fishes do, and, in the second place, only those two years old or more would do so, for the one year old ones winter in the sea-weed. This possibility is therefore anything but probable. When the full-grown specimens from last year disappeared from our shores after having finished the deposition of the eggs, there is consequently only one possibility left, that *they must die all of them. Spinachia vulgaris therefore must be looked upon as an annual animal, i. e. the individuals live only one year.*

But, it may be said, cannot it be proved directly then that the fishes die when the eggs are laid and the development of the young ones is over? Are not the dead fishes at that time found in numbers along the shores on low water where, when alive, they were seen in such multitudes? The answer to these questions must be no. Under the usual, natural circumstances it is impossible to prove anything of the kind; for whereever there are such great numbers of hungry rapacious fishes and crabs as here in Fænø Sound, even the greatest multitudes of only sick *Spinachia* will scarcely be permitted to live for one night. Nobody who has seen in how short a time (1—2 hours) the bait on 2—500 hooks, or even more, is quite devoured, will be surprised at this, and every one who knows the cod's and the eel's nightly razzias into low water to seek the food which their fear of the daylight prevents them from seeking in the day, will understand that it is even possible that the greater part of the *Spinachiæ* perhaps do not even get time to die a natural death, but are eaten as soon as they show but any sign of weakness, or slowness, and from this reason are unable to hide themselves with their usual rapidity. Nay, it is even possible that the *Spinachiæ* do not even become ill, but are regularly devoured every year in the months of June and July at the time when the eel awakens from its hibernation, and greedily falls upon all things living. Yet, if this were the case we should expect that the young ones from this year, which in July and August have already reached a considerable size, were eaten too, and as this does not occur we must suppose particular reasons, as sickness and death, or sickness alone, to explain the disappearance of the older fishes. — In open nature, therefore, we cannot in general expect to find any greater number of dead *Spinachiæ* at any time, and even if they were

there, they would be difficult to point out, more difficult than the living ones; but if we made a fence of nets on the low water where these fishes live, and so kept out the rapacious fishes we might expect to find such dead specimens. This year (1892) I had such a fence, with a diameter of 10—12 feet, made in Fænø sound and peopled it with ca. 150 *Spinachiæ* some of which also commenced to build their nests in the zostera bushes. The mortality among these 150 was quite enormous, but I cannot say with certainty wether this was owing to the narrow space in which they lived or whether they died in the ordinary way from such reasons as I have mentioned above. I feel most inclined, however, to believe in the latter hypothesis, as I have formerly had *Spinachiæ* living for a long while in a very limited place, just *till* the breeding-time was over. — It would be interesting therefore to make the experiment once more in another year, if possible on a greater scale. But wether or no we shall succeed in solving the question in this way, I cannot doubt now that *Spinachia vulgaris* in the course of one year attains sexual ripeness and then is full-grown; as also, that the whole stock of one year old fishes after the first breeding-period in May—June dies away in the course of very few weeks, so that large specimens are very rare already in the month of July.

It has hitherto been proved with respect to very few fishes only that they are annuals, in the above-mentioned sense of the word. Many become full-grown in one year, I think, especially smaller fishes as perhaps stickle-backs, certain *Gobiidæ*, etc., but as far as I can tell, no other fishes than *Aphya pellucida* and *Chrystallogobius Nilssonii* have been supposed to be annuals, and with the exception of certain species of *Petromyzon*, as also perhaps *Conger vulgaris* and *Anguilla vulgaris*, I know no other species of fishes whose individuals are regularly destroyed shortly after the breeding.

The conditions of the bottom, and the vegetable and animal life at Fænø.

In the chart I have, in broad features, given a representation of the depths of the seas around Fænø, as also of the occurrence of vegetation here. When we compare it with the chart of *Holbæk Fjord* (Report from the Biological Station, I) we shall see that the depths at Fænø are far greater in *Fænø Sound* as well as in the *Lesser Belt, properly so called,* viz. as great as 43 fathoms. The Belt itself forms a deep, narrow channel, which from Fredericia runs down past Fænø and farther towards the south. *Fænø Sound* must be looked upon as a separate part of this channel; at one place it is only 9—10 fathoms deep. — The fjords, *Gamborg Fjord* as well as *Kolding Fjord* with its two divisions, on the other hand, resemble *Holbæk Fjord* with respect to the depths, and we are not surprised to see that the conditions of the bottom are quite analogous in these seas: there is first a *sea-shore belt*, then a *zostera belt* in which there are spots of mud deposits, an then the *real, naked mud deposits* in the central parts of the fjords.

The *zostera belt* may here, as at Holbæk, be devided into two divisions one, nearest land, with *narrow-leaved* zostera, and another with *broad-leaved* zostera; but these two zones are not marked separately in order not to crowd the chart.

The *sea-shore belt* as also the belts of *zostera* and *naked mud deposits* are so closely described with respect to the Holbæk Fjord, and they agree so closely with the natural conditions there, that I consider a detailed description of them with respect to these seas rather superfluous, especially with respect to the *Gamborg* and *Kolding Fjords;* but it must not be left unmentioned that the *sea-shore belt* as well as the *zostera belt* along the shores of the *Lesser Belt* properly so called, with its rapid current, present certain dissimilarities to the natural conditions in the Holbæk Fjord. These zones are very narrow at Fænø (as will be seen from the chart), on account of the steep shores; only farther southwards in the Lesser Belt, at Føns-Skov and at Stenderup, is the zostera belt somewhat broader; at some few places, as at the northern side of Gals Klint and at Middelfart itself, are the shores even so steep *that there is no zostera belt at all.* In stead of that we find here a new belt which is not known at all in Holbæk Fjord, viz. the *algæ deposits,* which at the said two places (as also at other places in our seas, for instance at the harbours of *Fredericia, Grenaa,* and *Frederikshavn)* directly touch the sea-shore belt, nay even must be said now and then quite to supplant it. For what I have called the sea-shore belt is the border where the ice in winter goes down to the bottom and spoils the vegetation; but where the hsores

are perpendicular, as at the above-mentioned places, the ice cannot remain, and a sea-shore belt, consequently, not be formed. Such perdendicular or nearly perpendicular shores consist always of the firm rock, of heaps of stone, or they are made artificially of bulwarks or the like. At all these places there can be no zostera, as this can grow only in loose deposits, and algæ only are found here in the topmost regions corresponding to the sea-shore belt. *Below* this algæ vegetation there may sometimes grow zostera, if the depth is not too great, and if the bottom consits of sand. But at the said places in the *Lesser Belt* the littoral zone of algæ is continued directly down into the deep, and spreads, as will be seen from the chart, over the greater part of the Belt properly so called, where the current is strong, and the bottom in consequence hard, consisting of gravel and stone.

The *algæ zone* occurs generally in the deep, in the Lesser Belt; but, as I have said, it may reach up to the surface where the natural conditions of the shores (their steepness, hardness) will permit, and at a few places we may see it attempt to send *outliers* towards land, across the zostera, where there are large stones.

The plants that are most characteristic of the upper parts of the *algæ zone* in the Lesser Belt are the *Laminariæ;* at the harbours they may be seen pretty numerously represented in a way which remembers us strongly of the conditions in the Swedish and Norwegian »*Skærgaarde*«. Many other characteristic plants are growing, however, in the algæ zone in the Lesser Belt, but I think it is superfluous to enter into a closer examination of this matter.

While the sea-shore belt reaches down only a few yards, the *zostera* goes down to a depth of 4—5, nay perhaps even 6 fathoms; in the fjords; however, it will scarcely go down any farther than 3—4 fathoms. The *algæ zone,* on the other hand, spreads far down into the deep, till at least 15 fathoms, but it is constantly decreasing in luxuriancy, and is almost quite missing on depths below 20—40 fathoms, as stated also in the chart.

Below the algæ zone, at places where the bottom is rather steep, we may set up another zone or region, characterized by the animals that live there, viz. a *zone of sponges.* It is generally very narrow, and is found only at a few places, for instance at the steep slope, east of Stenderup forest. This zone is peopled with *Sponges* in great numbers, together with *Hydroidæ, Actiniæ, Gymnobranchia* (Dendronotus), *Annelida,* etc. Below this comes the flat, waste plains of gravel and stone where nearly all animal and vegetable life is missing. These parts are called, in the chart, the *naked sand and gravel deposits,* and correspond in some way to the naked mud deposits in the fjords; but they have not the rich animal life which we find here. While the *mud deposits* in the fjords, which occur already on a depth of only 4—7 fathoms, are uninhabitable for algæ, because these can find no sufficient hold there, the barrenness of the *naked gravel deposits* is evidently owing to want of light.

The chart shows that the *soft mud deposits* of the fjords meet with the *hard algæ zone* of the belt at the mouths of the fjords, but in reality the boundary line of course is not sharp at all, and is actually removed, I dare say, at certain times when the force of the current is changed. For there can be no

, that it is the rich vegetable and animal life in the fjords, and the clay
d into them from rivulets, brooks, etc., wich have afforded the materials out
ich these mud deposits have been formed. These materials have been able
·umulate in the fjords, where the waters are proportionally calm, but they
ashed away, when they enter the rapid current in the Belt properly so called.
d, it is sufficient just to look at the water in these seas, in order to be con-
d of this; for while the water in the belt is most frequently clear and trans-
t, that in the fjords is muddy and opaque.

While the Belt has thus its original bottom uncovered by more recent layers,
rhaps even hollows out its bed like a river, one layer after another is depo-
in the fjords over their original bottom.

As a matter of course there were in the *Holbæk Fjord* nothing correspond-
to the *algæ zone* and the *naked gravel deposits* in the Belt, neither, indeed,
ing like the intermediate *zone of sponges*. —

In Fænø Sound itself the following animals are generally found on the
oo deep *algæ zone*.

Of **Crustacea**: Hippolyte sp., Crangon vulgaris, Caprellidæ, and other Gammaridæ.

Of **Mollusca**: Some *Gymnobranchia, Buccinum undatum*, Fusus antiquus, Velutina, Piline aperta, Odostomia, Tectura, Chiton, *Cyprina islandica*, *Astarte borealis* and compressa, Cardium fasciatum, *Abra alba, Modiolaria discors* and nigra, Mytilus edulis and modiolus, *Saxicava*, Mya truncata.

Of **Ascidia** among others *Ciona canina* and *Cynthia grossularia*.

Of **Bryozoa** frequently *Gemellaria*, Alcyonidium, etc.

Of **Annelida**: *Lepidonotus*, *Nereidæ* and *Terebella*, etc. Many **Hydroidæ**, **Actiniæ**, and **Sponges**.

Of **Echinodermata**: *Asterias rubens, Echinus miliaris*, and *Ophioglypha albida*, as also rarely a little Solaster papposus or a Cribrella.

In this region we find a great number of *Cod*, which feed on almost
the said species of animals; at certain times there are *Plaice, Flounder,* and
mon Dab; Liparis seems to be there constantly; for we find very often its
gs in this region at the »root« of the *Laminariæ*.

At the above-mentioned places at Gals-Klint and at the harbour of Middel-
t, where the algæ zone reaches up to the very surface of the water, it is
narkable to see that also a great number of its fauna follows it, for instance
crinum, which may be taken here with the hands. In other of our seas, where the
ores slope down smoothly, and the deep from this reason is miles away from
e beach, we look in wain for *Buccinum* on the shore; but here, where
e deep is only a few hundred feet from the beach, certain animals belonging to
e fauna of the deep are able to go in to the shore quickly, when the weather
rmits, and to go away again as quickly, if for instance the ice sets in. — That
e animals which cannot move are much exposed to freezing to death in these
most regions, is easy to see every year when there has been a strong frost
th ice, for *Mytilus*, for instance, sits then in great numbers on the harbour
ildings with its *shells half opened* and the soft parts of its body rotten, still
osely attached by its byssus-threads, but ready to fall of at the first strong

lashing of the waves. To dig up *dead worms and dead digging bivalves* from the sea-shore after a hard frost is also a very common thing.[1]) — That the animals on the deep are far better protected against the frost than those on low water, is a well-known thing; on the deep, therefore, many animals are able to live, which cannot bear the cold in the higher regions, and which will be killed, consequently, when they incautiously approach too near the beach, if they are unable to go quickly away again to the deep. While the deep, therefore, can show a rich fauna all the year round, the sea-shore belt will have only a fauna which immigrates every year, or is very hardy; it is, in consequence, only a scanty fauna it can have.

There is, as above-mentioned, at a few places on the deep, below the algæ zone on the steep slopes, for instance east of the Stenderup forests, a special region, *the region of the sponges,* distinguished by an extreme richness of animal life, while the vegetation is quite missing. Below this narrow zone are the large, waste *plains of gravel and sand* whose organic life consits exclusively in some single *Actiniæ* and *Edwardsiae*, a few *Montacuta bidentata,* one single *Modiolaria nigra,* a few *Cynthia* and a few *Annelida,* a region which, with regard to species, is the most barren I have seen anywhere in our seas. In this region the fish come but rarely and, I dare say, never to seek their food. —

It have both at *Holbæk* and here in the *Lesser Belt* attached great importance to the exploration of the extent of the various regions or zones of the sea, for the occurrence of the fish is to a very high degree dependent on them, and it is my hope at some future period to be able to map down all these regions throughout all the Danish seas. Such a map will explain much about the different importance of the fisheries at the various places, explain for instance, why at certain parts the plaice-fishery, at others the eel-fishery, is of such a different value. As yet we have too few data for the drawing of this map of the seas around the isles of Funen and Zealand; yet so much I think I may say that in such a map we must lay down the following *main regions:*

1) *The sea-shore belt.*
2) *The two belts of zostera*, with a substratum of sand and gravel, partly of mud in the fjords.
3) *The algæ zone*, with sand and gravel (stone) as a substratum, or of mixed deposits and deeper water.
4) *Naked gravel and sand deposits*, on deep water.
5) *Mixed deposits* without any plants, on deep water.
6) *Naked mud deposits* without any plants, in the fjords.
7) *Naked clay deposits* on deep water, in the more open seas.

When we have drawn such a map, it will show us many things, with respect to what fisheries we may carry on at the various places as also to the economical importance, greater or smaller, which these may be supposed to get. In other words: we shall then have a »valuation« of our seas.

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[1]) It is not always possible to tell whether these animals have died with cold, or have been killed by the fresh melting water under the ice; at any rate, however, the cold is the cause of their death in both cases, either directly — or indirectly.

The Temperature in the bottom of the sea.

We must not think that every animal on the bottom of the sea is quite abandoned to the mercy of all the changes in the temperature of the water. It has for instance long been known that many animals, such as the *eel*, in winter-time bore down into the bottom of the sea and lie in a sort of torpid state; and it has, possibly, been thought also that this was owing to the low winter-temperature. That the temperature is higher in the bottom than in the water has never been proved, however, as far as I know. In the winter 1891—92 I therefore examined this question in the Kolding Fjord, on about two fathoms of water, a well isolated thermometer being fixed to a long pole which was rammed down into the soft bottom of the sea. It was seen then that even when the temperature of the water was about 0°, the temperature 3—4 feet down in the mud was c. + 7° C. through the whole winter, *consequently a little below the average temperature of the air for the year*, and probably *just equal to the average temperature of the water*. It is quite possible that we need not always go down into the mud as far as that to find + 7°; but even then the topmost parts of the mud must be somewhat warmer than the water*) There is no doubt that many animals make use of this high temperature of the mud in winter-time; that *Gobiidæ*, *Rissoa*, *Cerithium*, *Trochus*, and certainly many others, bury themselves in the bottom during the winter has been observed by *J. Collin* (»Om Limfjordens marine Fauna 1884«) and by myself, but there is no doubt neither that other animals, as the *Ciona canina*, cannot do so.

If we measured the temperature in the bottom in this way at many places in our seas, it is quite possible that we should be able to get a general view of *the average temperature of the water* at the various places; in any other way this is very difficult, as it is in most places nearly impracticable, on account of the ice, to measure the temperature of our seas in the usual manner without any interruption.

When a great part of our fauna lies dormant in winter-time (and so do for instance both Palæmon and Carcinus), then it is clear that a tool like the eel-spear, which just at these places cuts through the bottom of our fjords everywhere, will bring death and destruction to a great number of animals, a destruction felt much more than that caused by certain seines in summer-time. For in the latter season the animals will often be able to live, even if they are torn away, and the multiplicity of individuals and the power of reproduction of the species are at this time of the year far greater. Even if the eels are only disturbed by the spearing, it is

---

*) 14. Nov. 91. Water 4,9°. In the mud 7,5°.
25. Nov. » » 2,6°. » » » 6°.
2. Dec. » » 3,5°. » » » 5° near the surface; but on 3 feet 8°. } Kolding.
19. Dec. » » 0°. » » » 6° near the surface.
1. Febr. 92. » 1,1° » » » on 4 feet 7°.
23. March » » 3,1° » » » » 4 » 7°.
11. Febr. 93. » + 0,1° » » » » 4 » 7°. Svendborg.

a matter of cource that they suffer much by being driven out of their caves in winter-time, and I have also heard complaints of this from the Limfjord.

A list of a number of *Invertebrates* from the seas around Fænø, partly determined by those students who during the summer have stayed onboard the Biological Station:

Protozoa: One Radiolar.
» Acineta.
3 species of Peridinia.
Spongiariae: 1 little one with calcareous spicula.
1 large yellow one with silicious spicula.
Hydroidæ: Gonothyrea Loveni.
Campanularia flexuosa.
Clava sqvamata.
Bougainvillea ramosa with Medusa.
Podocoryne carnea (on Nassa reticulata).
One Steenstrupia Medusa (perhaps belonging to Corymorpha nutans
Tabularia humilis, coronata and indivisa.
The Medusa belonging to Obelia dichotoma.
Sertularella rugosa.
Sertularia abietina and pumila.
The Sarsia tubulosa Medusa.
Acalephae: Aurelia aurita.
Cyanea capillata.
Ctenophorae: Pleurobrachia pileus.
Bolina alata.
Idyia cucumis.
Actiniæ: Actinoloba dianthus.
Edwardsia sp.
Bryozoa: Flustrella hispida.
Alcyonidium gelatinosum.
» Mytili.
Crisia eburnea var. producta.
» var. cornuta.
Gemellaria loricata.
Tubulipora sp.
Flustra foliacea.
Membranipora pilosa.
» membranacea.
» monostachys.
» lineata.
» aurita.
Cribrilina punctata.
Lichenopora hispida.
Valkeria uva.

Echinodermata: Asterias rubens.
Solaster papposus.
Cribrella sangvinolenta.
Ophioglypha albida.
Echinus miliaris.
Worms: Nereis pelagica.
» Dumerilii.
Arenicola marina.
Nephthys coeca.
Nicolea zostericola.
Syllis sp.
Terebella sp.
Spirorbis borealis.
Serpula sp.
Leptoplana sp.
Crustacea: Palæmon Fabricii.
» serratus.
Palæmonetes varians.
Hippolyte Gaimardi.
Carcinus maenas, in all ages.
Diastylis Rathkii.
Lamprops sp.
Cuma sp.
Gasterosaccus sanctus.
Mysis, many species.
Proto ventricosa.
Caprella sp.
Dulichia porrecta.
Talitrus sp.
Other Gammaridæ.
Hyperia galba, in numbers.
Jæra sp.
Eurydice pulchra.
Idothea marina.
Podon sp.
Evadne Normanni.
Temora longicornis.
Dias longiremis.
Notodelphys Almanni.
Pycnogonidæ: 2 species.
Pteropoda: Clione limacina.
Gymnobranchia: Doris muricata.
» pilosa.
» proxima.
Æolis Drummondi.
» exigua.

Gymnobranchia: Dendronotus arborescens.
Univalves: Odostomia sp.
Utriculus.
Philine aperta.
Akera bullata.
Littorina littorea.
» obtusata var. fabalis.
» rudis var. tenebrosa.
Lacuna divaricata.
« pallidula.
Hydrobia sp.
Rissoa membranacea.
» inconspicua.
Cerithium reticulatum.
Velutina lævigata.
Fusus antiquus.
Buccinum undatum.
Nassa reticulata.
Acmæa testudinalis.
Chiton sp.
Bivalves: Mytilus edulis.
» umbilicatus.
Modiolaria discors.
» marmorata.
» nigra.
Cardium edule.
» exiguum var.
» fasciatum.
Astarte borealis.
» elliptica and sulcata.
Cyprina islandica.
Abra alba.
(Scrobicularia plana?)
(Tellina calcarea?)
Tellina baltica.
(Solen pellucidus).
Montacuta bidentata.
Corbula gibba.
Saxicava rugosa.
Mya arenaria.
» truncata.
Pholas crispata.
Teredo sp. sp.

I am myself responsible for the determination for instance of the testaceous mollusks. The list of these might be made somewhat longer by additions from my earlier works (»Hauch«s Togter); but because an animal lives in the Lesser Belt for some

ears, it is not sure that it lives there always. The list I have given here is based nly on my own finds in 1891—92. — All testaceous mollusks which are mentioned ere, with the exception of *Rissoa inconspicua,* are stated to be found also in the estern part of the Baltic Sea at Kiel, with whose fauna that of the Lesser Belt lmost quite agrees; *Triforis perversus, Bela turricula, Astarte Banksii,* and *Pholas indida* being the only ones I have not seen in the Lesser Belt. The fauna of ie western part of the Baltic is perhaps somewhat richer than that of the orthern parts of the Lesser Belt, which agrees with the near connection between ie western Baltic and the Great Belt, and with the above-mentioned hydrographical conditions which are the results here of.

On the fishery at Fænø and in the neighbouring seas.

Contrarily to what we find in the Holbæk Fjord there are in the Lesser elt south of Middelfart only one or two *poundnets* which are used for *herring-shery* in *spring*. It seems as if poundnet-fishery cannot advance very far outh of Fredericia and, particularly, Baaringvig, though several attempts at it are aid to have been made. This is so much the more remarkable as there is no ant of herrings, at any rate not in the *Kolding Fjord;* they use here the so alled *herring-seines,* which, however, also catch *cod, trout,* and a few other species f fishes, and which might just as well be called *cod-seines*. They are of German Sleswick) origin, and are in our country particularly used in the Lesser Belt and 'ejle Fjord. They are essentially different from the large *herring-seines properly* o *called,* which are used for catching herrings, for instance in the Limfjord and t Faaborg. Another way of fishing herrings (also of German origin) is to catch hem with little bright brass *hooks* on a horse-hair line; there is no bait on the ooks, of which there are two on each line; with both hands these are kept in a onstantly snatching motion, the fisherman having one line in each hand. This ay is used especially at two places in the Koldingfjord: at Løger-Odde in spring nd early summer, and at Løver-Odde in autumn; it is used during a great part f the year, midsummer and midwinter however excepted, for at these times the erring seems to be rather scarce. In autumn they fish with *herring-gill-nets* in the ery narrows of the Belt.

When, as it happens in some years, shoals of *garfish* and *macherel* come n here, they are persecuted with gill-nets and seines besides with the few poundnets t Middelfart; only very small quantities of these fish were caught however in 891 & 92.

The *cod-fishery* is carried on all the year round in the *current* with and-line and hook; it seems most profitable from the beginning of September till owards Christmas, as also now and then in spring.

Cod-fishery in *weels* is chifly carried on in the fjords, though of course ot in the deep parts of the Belt, from September—April, and seems to become ore common from year to year.

In summer the *plaice-fishery* is carried on, on the algæ bottom, partly also n the mud deposits of the fjords, with *gill-nets, hooks* and in the very latest years

also with *seine* (»Snurrevaad«) which can be used only where the bottom is not too rough. This fishery seems here to give, on the whole, much larger plaice than the two other fisheries; the large plaice are not always willing to swallow the bait, and cannot be caught in the gill-nets, which have generally little meshes; as there is now, as above-mentioned, only a very small quantity of quite young plaice in these seas, in contradistinction to the Kattegat properly so called, the result is that the catches of the seines generally consist of larger fish than those of the gill-nets; for these cannot catch the largest fish.

In the fjords are caught a quantity of *flounder and common dab,* which are sold in the neighbouring towns, chiefly in Kolding. *Prawn*[1])*-fishery* with *weel-* and *prawn-catchers* is carried on in Gudsø-Vig and Gamborg Fjord, but is of no greater moment.

Eeel-fishery is carried on with *hand-seines* (»Haandvaad«) in the fjords, on the borders between the zostera and the mud deposits, and with *drift-seine* (»Drivvaad«), chiefly in the zostera-belt in the Kolding and Gamborg Fjords, but also at other places where zostera is found, in the narrows of the Belt, in the expansion south of this, the »Binderup Bugt«, and on Flækøjet. *Drift-seine* fishermen live in great numbers at Skjerbæk, but they fish during the greater part of the summer at Lolland and other places, and do not go home to the Lesser Belt till towards autumn, when they continue fishing as long as it pays. In the end of the fishing-season, therefore, they often collide with the cod-weels in the outmost part of the Kolding Fjord, yet apparently without getting into any serious conflicts. — The eel hand-seines catch, besides eels, also vivip. blenny, flounders, and a few cods, which gives them a somewhat higher value. The drift-seines also get something, chiefly vivip. blenny and cods, besides the eels, and they catch especially many codlings, which are without any value as food, and of which a great number die. The before-mentioned cod-seines, which are used also in winter, are said, at times, to catch still greater multitudes of codlings.

Eel-spearing in winter is of little moment as there seem to be too few eels in the Fjords to pay the trouble. — In summer some eel and trout are speared in calm nights by lantern-light.

Eel-hooks are used very little, and cannot be used at all at most places, as the codlings swallow the bait before the eels find them.

The *eel-weel* fishery is, I think, the most important fishery in these seas; it is only carried on along the shores of the Belt properly so called by means of eel-weels that fish from the south. The leader is generally of string and at a few places, in the very surf, of wickerwork. In the narrows of the Belt the »*Aale-Gaarde*« (i. e. rows of eel-weels) are only short, as they are not carried out on more than a depth of 10—12 feet at the fore-bows of the weel, but the weels are very large, more than 6 feet high in the forebow. To the south, along *Føns-Skov* and at the opposite shore of Jutland, they use whole rows of smaller weels, the so-called »Kasteruser«, fastened to stakes.

In the eel-weels are caught, besides eels, also vivip. blenny, *cod* in great numbers, and often some few *flounders and common dabs,* sometimes *trout* and *salmon*, nay

[1]) Danish *Reje* = *Palæmon Fabricii. Rtk.*

garfish, when emigrating from the Baltic Sea, and *shoals of herrings* may sometimes get into the large weels. — At times, it is said, many young *codlings* will get into the weels, but they die when taken on board, as they are generally mixed up with mucus of eels, eels, and shoals of medusa. I myself never saw quite small codlings in the weels, and the fishermen said also that none at all were caught in the two years I stayed there.

The eel-fishery with weels lasts from September till towards Christmas, which is longer than on most of our other shores.

When this fishery is of such great moment in the Lesser Belt, the reason is, of course, that great numbers of silver eels (migrating eels) go through the Belt from the inshore waters of the Baltic on their way towards more open seas; these shoals will often, perhaps, considerably multiply the number of eels which otherwise would come from the neighbouring waters.

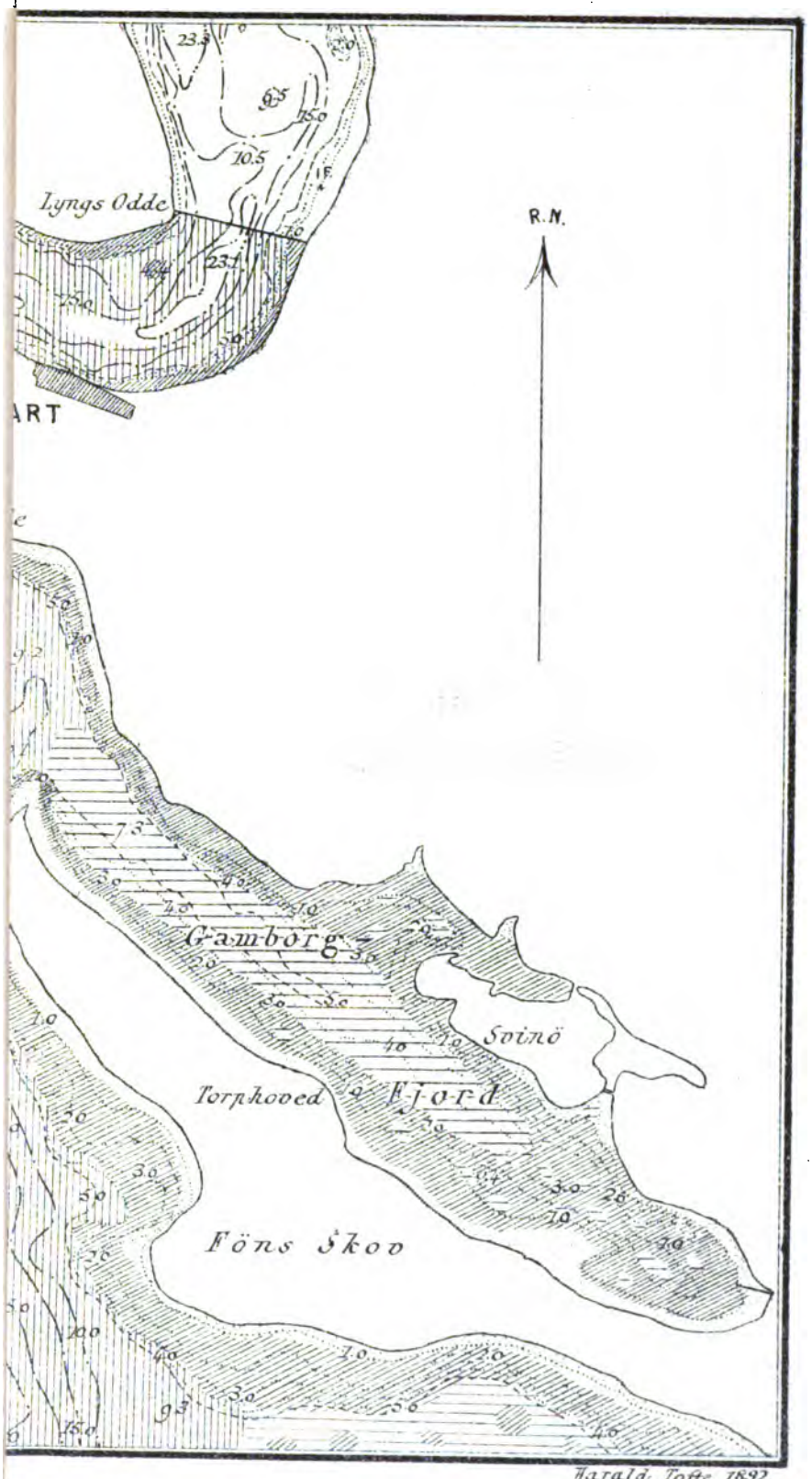
The fishermen often complain that this eel-fishery has decreased much during these two or three decades, and no doubt they are right. But the explanation is very simpel: when more and more weels are set out in the southern part of the Belt (and this has been done), and the eel-seines moreover diminish the stock of yellow eels, the number of silver eels which go through the Belt must necessarily grow smaller. The eel-seines also catch the silver-eels both in Kolding and Gamborg Fjord (»Sand eels«) though not in such numbers as might be thought, and they catch also eels which, in the course of a few weeks, would have become silver eels. By picking out such eels as by their appearance (the scales stand out more distinctly than usual) made me suppose that they would become silver eels this autumn, and keep them in the tank onboard, I made sure, repeatedly, that yellow eels really in a few weeks can become silver eels. This occurs in salt-water, yet, I think only in the months of August and September; at other times, at any rate, *I have been unable* to find yellow eels of such an appearance.

While in the Holbæk Fjord they had only a considerable fishery of 1) eels with seines and hooks, 2) herrings in poundnets and gill-nets, and 3) flounders, we have here in the neighbourhood of Fænø, besides the same fisheries, which however with respect to herrings take other forms, also a rich *cod-fishery*, *plaice-fishery* and *fishery of eels in weels*. It will be hard in our narrow inshore waters to find more different conditions than in these two seas. The above statements will show why it must be so. The causes must be looked for in the different conditions of the bottom of the two seas, in their hydrographical conditions, and the situation of the Belt between the Baltic Sea and the Kattegat.

Contents.

	Page.
The pelagic life in Fænø Sound	1—11
Pelagic eggs of fishes in the Lesser Belt 1891—92	11—15
The common dab (Pleur. limanda). With Table I.	16—18
The flounder (Pleur. flesus). With Table II.	18—19
The cod (Gadus callarias). With Table III.	19—21
The eel (Anguilla vulgaris). With Table IV.	21—23
Aphya pellucida	23
Spinachia vulgaris (an annual fish)	23—26
The conditions of the bottom, and the vegetable and animal life at Fænø. (With a chart.)	27—30
The Temperature in the bottom of the sea	31—32
A list of a number of Invertebrates from the seas around Fænø	32—35
On the fishery at Fænø and in the neighbouring seas	35—37.

Each of the signs • or › in the tables I—IV indicates a fish measured in Danish inches, from the tip of the snout to the end of the caudal fin. — A Danish inch = $^1/_{12}$ foot = $26{,}_{15}$ mm. — In the tables a › indicates that the fishes were near spawning, or had spawned very recently. A • indicates nothing about the condition of the generative organs, when used alone in a column. Are both › and • used in the same column, the • indicates that the fishes were not near spawning, or could not with certainty be said to be near spawning.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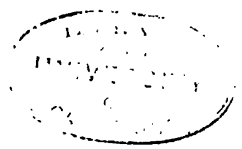

aa.	S. for Endelave.	Ø. for Ende-lave.	Æbelø.	Midt paa Aalborgbugten. (In the middle of Aalborgbugten).	
1892. avne. urre- d. athoms . l. m.)	21. Juni 1892. 14 Favne. Sm. Snur-revaad. (14. fathoms Seine w. l. m.)	21. Juni 1892. 8 Fv. S. S. (8. fath. Seine w. l. m.) (Hauch).	25. Juni 1892.	27. Juni 1892. 5 Favne. Sm. Snurrevaad. 5 fathoms (Seine w. l. m). (Hauch). Færdig med Legen. (Spawning over).	
♂	♀	♀	♀ ♂	♀	15
					14
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ind.	Svendborg.	I en Aa ved (In a riwelet near) Lundeborg.	
892.	4. Sept.—11. Okt. 1892.	30. Sept. 1892.	
e.). ydende awning)	aad og Ruser. ine and weels).	Reiehov, (Prawn-catcher).	
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ınd.	Svendborg.	I en Aa ved (In a riwelet near) Lundeborg.	
1892.	4. Sept.—11. Okt. 1892.	30. Sept. 1892.	
e. 1). (ydende awning)	Faad og Ruser. (Line and weels).	Reiehov, (Prawn-catcher).	
	♂	♀	
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